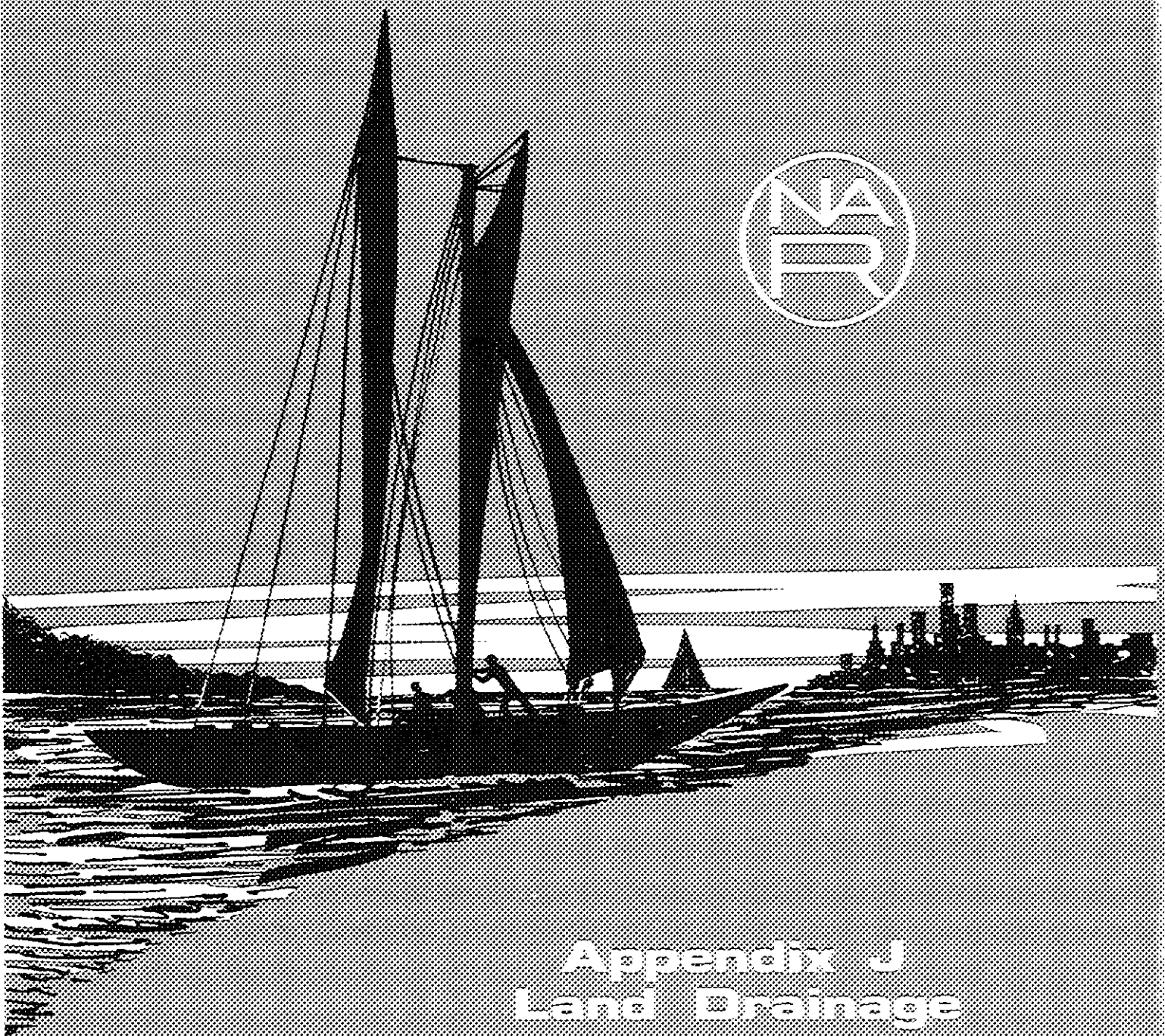
North Atlantic Regional Water Resources Study



Appendix J
Land Drainage

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY COORDINATING COMMITTEE
MAY 1972

The North Atlantic Regional Water Resources (NAR) Study examined a wide variety of water and related land resources, needs and devices in formulating a broad, coordinated program to guide future resource development and management in the North Atlantic Region. The Study was authorized by the 1965 Water Resources Planning Act (PL 89-80) and the 1965 Flood Control Act (PL 89-298), and carried out under guidelines set by the Water Resources Council.

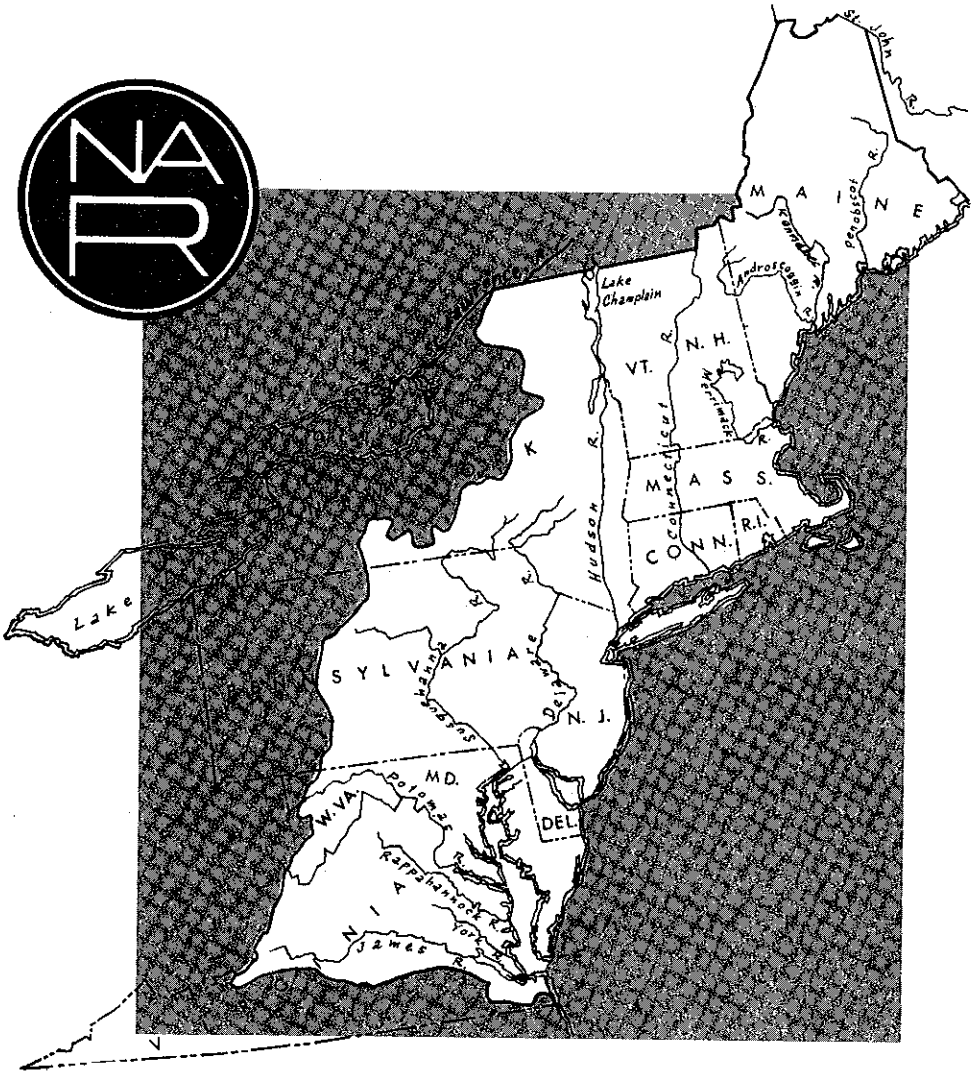
The recommended program and alternatives developed for the North Atlantic Region were prepared under the direction of the NAR Study Coordinating Committee, a partnership of resource planners representing some 25 Federal, regional and State agencies. The NAR Study Report presents this program and the alternatives as a framework for future action based on a planning period running through 2020, with bench mark planning years of 1980 and 2000.

The planning partners focused on three major objectives -- National Income, Regional Development and Environmental Quality -- in developing and documenting the information which decision-makers will need for managing water and related land resources in the interest of the people of the North Atlantic Region.

In addition to the NAR Study Main Report and Annexes, there are the following 22 Appendices:

A. History of Study
B. Economic Base
C. Climate, Meteorology and Hydrology
D. Geology and Ground Water
E. Flood Damage Reduction and Water Management for Major Rivers and Coastal Areas
F. Upstream Flood Prevention and Water Management
G. Land Use and Management
H. Minerals
I. Irrigation
J. Land Drainage
K. Navigation
L. Water Quality and Pollution
M. Outdoor Recreation
N. Visual and Cultural Environment
O. Fish and Wildlife
P. Power
Q. Erosion and Sedimentation
R. Water Supply
S. Legal and Institutional Environment
T. Plan Formulation
U. Coastal and Estuarine Areas
V. Health Aspects

Appendix J
Land Drainage



Prepared by

North Atlantic Regional Study Group
North Atlantic Division, Corps of Engineers
and the
Economic Research Service, Forest Service
and Soil Conservation Service
United States Department of Agriculture

for the

NORTH ATLANTIC REGIONAL WATER RESOURCES STUDY
COORDINATING COMMITTEE

SYLLABUS

Appendix J, Land Drainage is the joint product of the Department of Agricultural and the Department of the Army, and is presented in a format emphasizing a detailed analysis and regional summary of agricultural land drainage, with an abbreviated report on major drainage efforts.

The North Atlantic Region experiences excess water problems on 17.2 million, or 16%, of its 105.7 million land acres. The primary causes of these excess water areas include overflow, high water tables and poor internal soil drainage.

While the subject matter of this relatively short Appendix is land drainage, its inclusion as a part of the North Atlantic Regional Water Resources Study should not be construed as a blanket endorsement of land drainage by the North Atlantic Regional Water Resources Study Coordinating Committee. It has been developed as a part of the many water and related land resources disciplines that must be considered in developing an alternative approach program for water management and development in the Region.

The Coordinating Committee recognizes the importance of the wetland resources of the NAR, and does not view land drainage as an entity in itself without the benefit of a full examination of the situation, including wetland protection and preservation programs. Federal, State, Regional and local agencies engaged in drainage programs, which may involve conflicts in wetland use and wetland preservation, must join together to formulate plans that meet the needs and requirements of the people of the North Atlantic Region.

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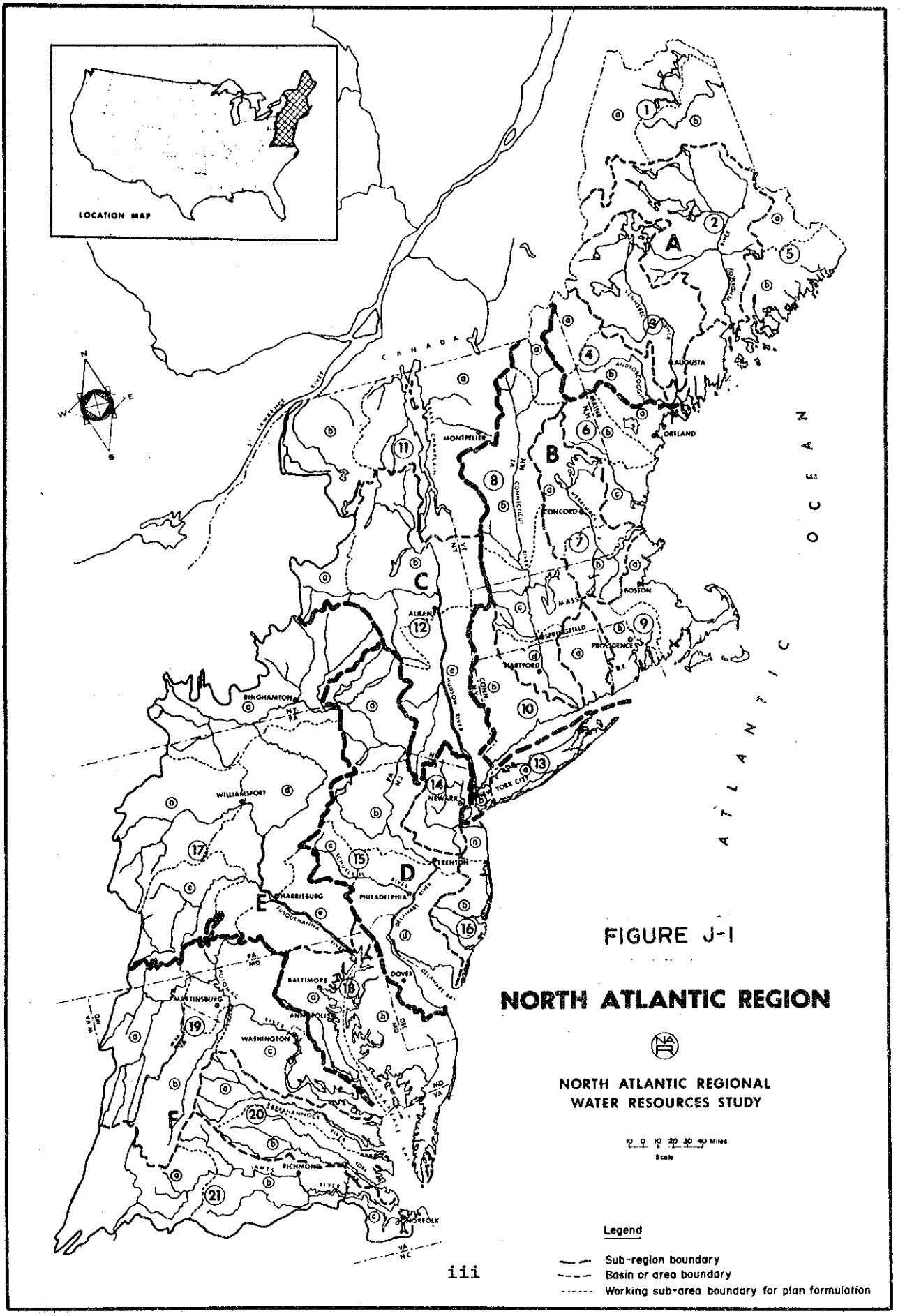
LOCATION MAP
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ALBANY
SPRINGFIELD
PROVIDENCE
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BINGHAMTON
NEW YORK CITY
NEWARK
TRENTON
PHILADELPHIA
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FIGURE J-1
NORTH ATLANTIC REGION
NORTH ATLANTIC REGIONAL
WATER RESOURCES STUDY
Scale
Legend
Sub-region boundary
Basin or area boundary
Working sub-area boundary for plan formulation

CHAPTER 1. INTRODUCTION

Excess water imposes limitations on the use of nearly one-fifth of the land area of the United States. In the North Atlantic Region, high water tables, overflow, wetness and poor internal soil drainage are dominant excess water problems on about 16% of the land area. Excess water on agricultural land causes substantial losses to the production of food, fiber and food products.

At the Federal level, land drainage is the responsibility of the Department of Agriculture and the Department of the Army acting through the Corps of Engineers. Agriculture, of course, has major responsibility for agricultural land drainage, while the Corps handles major drainage.

PURPOSE AND SCOPE

PURPOSE

Appendix J provides general information relating to land drainage and identifies and evaluates potential land drainage needs, and measures for meeting these needs. The resulting costs and benefits of these potential solutions are also developed, as are their overall effects on the Region. Information developed herein has been utilized in the plan formulation process for developing alternative water and related land resources development and management programs for the NAR.

SCOPE

The Land Drainage Appendix covers the extent of major and agricultural drainage problems, land drainage improvements, and their economic and hydrologic effects to a degree of refinement consistent with developed guidelines for comprehensive Type I framework studies. Information on land use and yields of areas adversely affected by excess water, production costs and returns, existing and potential land drainage improvements, and fish and wildlife wetland development provided assistance in analyzing and correlating the drainage data to all aspects of water and related land use.

Regional wetlands considered for potential improvement include coastal marshes and land areas in the flood plains of major streams, rivers and estuaries. These wetlands are important to the production of food and fiber, the spread of urbanization, the expansion of commerce and industry, the propagation of fish and wildlife and to recreation. These wetlands also have a variety of other tangible and intangible values.

Data for this Appendix was drawn from available information,

and data deficiencies are noted as further research or field investigations are not within the scope of the NAR study.

HISTORICAL BACKGROUND (1)[1/]

The origin of land drainage in the United States goes back to the nation's earliest settlement days. There were millions of acres of wetland, and the most accessible and most potentially productive land was located in the valleys of rivers and streams and in coastal, estuarine and lake tidal plains. The use of much of these lands, however, was constrained by an overabundance of water.

During initial colonization and settlement, land drainage was mostly the undertaking of farmers, as agricultural development was vital to national growth. The Dismal Swamp areas of Virginia and North Carolina were first surveyed by George Washington in 1763 with an eye toward land reclamation. Constructing small open ditches and cleaning out small natural streams was colonial-era work in Delaware, Maryland, New Jersey and Massachusetts.

John Johnson molded and placed the first drainage tile in 1835 on his Seneca County, New York, farm. During the next 50 years, settlers used closed drains to convert millions of nontillable acres to fertile farmlands. Success of many tile systems depended on large outlet ditches. Such ditches thereby afforded agricultural development of large new tracts of land. Even before the turn of the century, elaborate projects were undertaken for flood control and drainage.

Mechanization made construction of large open itches and installation of tile drains more economical. Until the appearance in 1883 of the first dipper dredge and steam engine-powered plumb ditching machines, drainage work was done by hand or horse teams and scrapers. Open ditches were seldom over five feet deep with a four-foot bottom width. Tiles were laid at a depth of 6 to 12 inches. The dragline excavator began to replace the dipper dredge in 1906. Modern diesel-powered, track-type draglines can dig ditches more than 20 feet deep with a 150-foot bottom width, efficiently and economically. Modern tile trenching machines can dig 2,000 to 3,000 feet of 1.5-foot wide and 6-foot deep trench a day. Pumps began to replace animal-powered drainage wheels used on sugar plantations as early as 1800. Low-lift centrifugal and screw-type pumps are now used on pumping projects. Earth moving equipment has made dike and levee construction easier. Means of construction are no longer a major limitation of drainage projects.

The Federal Government was involved in only a small amount of direct land drainage before the emergency public works projects in the 1930s. The Swamp Land Acts of 1849 and 1850, the first important Federal drainage legislation, were almost the only stated Federal policy for over 75 years. Under these Acts, millions of acres of

1/ Numbers in parentheses refer to Bibliographical references on pages J-62 and J-63.

swamp and over-flow lands were conveyed to States to facilitate reclamation for agricultural uses. These acts were also intended to promote agricultural development and provided for active public participation in drainage activities. A result of that action is that many of the lands drained during that period are, today, among the most productive agricultural lands, are extensively urbanized and are the locations of much commercial and industrial development.

Subsequent to the Swamp Land Acts, Congress has enacted numerous flood control, reclamation, and watershed management bills providing for water flow regulation and other drainage measures. The intent of these later acts, however, was mostly piece meal single project effort of localized effectiveness.

From 1925 to 1940, the chief Federal concern was rehabilitating drainage enterprises suffering economic distress. Direct assistance was provided through the Civilian Conservation Corps. Technical assistance was available from USDA's Soil Conservation Service.

However, in 1927, Federal legislation provided for comprehensive river basin studies which were implemented in the 1930's. This legislation directed that consideration be given to all water and related land resources needs.

Between 1940 and 1960, this comprehensive planning concept actually became a reality. In the Flood Control Act of 1944, Congress authorized work on channels and major drainage improvements as a part of the national flood control program. Under the Act, main river channels and major outlet channels that serve many existing enterprises can be improved if the work is of widespread public benefit. The Corps of Engineers was for the first time instructed to engage in drainage work not directly related to levee building and other flood control projects.

A new stage in Federal policy relating to drainage was reached with the enactment of the Watershed Protection and Flood Prevention Act of 1954, which authorized the Department of Agriculture to cooperate with States and local agencies in planning and carrying out works of improvement for soil conservation and other purposes, including land drainage.

In the Water Resources Planning Act of 1965, Congress directed that the conservation, development and utilization of water and related land resources shall be planned and conducted on a comprehensive and coordinated basis. The Act established a Water Resources Council of cabinet level members, Federal-State river basin commissions, and authorized financial assistance to the States for comprehensive planning.

More recent legislation, such as the National Environmental

Policy Act of 1969, and the establishment of the Environmental Protection Agency, recognize environmental quality eminence and will impose significant altering effects on past land drainage practices, concepts and attitudes and, of course, will bring new modes to this discipline.

Drainage laws in most states have been developed gradually from time of settlement as larger and more costly improvements have been planned. Resolution of inconsistent amendments, revisions and reamendments without considering the law as a whole, maintenance provisions, assessment of benefits, financing methods, and simple procedures for small enterprises are problems which the states need to confront. Accordingly, the existing laws need to be improved.

Drainage districts or corporations and county governments are the most common forms of organization to carry out drainage work of public concern. Provided under State enabling Acts, either type of organization is effective when properly administered.

Mutual group enterprises are often used to overcome common drainage problems. The cooperative groups avail themselves of technical assistance provided by the Soil Conservation Service.

It can be seen that land drainage has been a continuous undertaking by both the private and public sectors. Land drainage has been of great impetus to national growth and to the well-being of the people. The approach to future land drainage activity, however, must be considered from a more enlightened point of view. It no longer holds true that indiscriminate drainage of wetlands is good for any immediate or long-term economic gain, if it is to imperil the balance of environmental stability.

BASIC CONCEPTS

Drainage is a discipline which varies according to the specific need for drainage, and the responsibility for implementation which is scattered among several agencies. As a consequence, the expression mode varies. For this reason, presentation of a cohesive drainage analysis would be difficult unless certain concepts are defined and discussed.

DRAINAGE

Drainage is defined as the regulation of water level, it is, for the related land resource, the design water control function regulating either or both surface and subsurface waters.

The commonly accepted concept of drainage is to regard it solely as a land reclamation measure. While it is true that land

reclamation is a drainage function, land reclamation is not its sole function. Drainage measures are used to satisfy demands upon the wetland resources such as needs for new land or, in reverse, the enhancement and preservation of wetlands, or to satisfy needs to promote health and well-being.

The concept of considering flood control, drainage, and irrigation as separate and distinct entities subject to individual treatment have been superseded by the current comprehensive exercise of the multiple purpose function of water control.

Major drainage and agricultural land drainage are defined in the chapters in which they are covered in detail.

WETLANDS

The term wetlands generally refers to lowlands covered with shallow and sometimes temporary or intermittent waters, often referred to as swamps, bogs, wet meadows, potholes, sloughs and river-overflow lands. (2) These various wetlands differ greatly according to their rates of discharge, recharge and water level fluctuations; their biological and chemical compositions; and their usefulness for flood control, wildlife, recreation and other purposes.

Wetlands can be drained or filled to create land for agricultural, industrial or residential expansion.

When considered strictly in the light of land drainage, wetland is often thought of as land on which excess water imposes limitations to some of its potential uses. It is land characterized by being constantly or periodically submerged or of having a constant or occasional high water table. Within the scope of this definition, wetlands includes agricultural lands on which excess water inhibits optimum agricultural production; overflow plains of streams, and estuaries and coastal littoral; and, such other tracts of low, wet, soft land variously known as swamps, marshes, bogs, morass and fens.

Some of the values of the wetland resource are tangible and measurable in economic terms while other values are entirely intangible but of increasing social importance. The nation's increasing population, fast economic growth, and accompanying extensive land development trends are placing a heavy demand on the wetland resources to accommodate urban expansion, increased production, fish and wildlife habitat, and recreational opportunities. The economic demands placed upon the resource are often in conflict. To compound these conflicts, there is a recently realized urgency of preserving social values, inherent in undisturbed wetlands, that satisfy a variety of esthetic, cultural, recreational, and environmental human wants. There is also an immeasurable significant scientific awareness of the ecological relations of the biotic complex of life generation in the wetland that is indispensible to biologic balance. Prevalent thinking on this matter recognizes the potential expanse of wetlands that could be drained or may be drained

to satisfy the economic demands for land, but is also aware of the necessity for recognizing and evaluating the value of the natural undisturbed wetland preserve.

National policy on the use of the wetland resource is in need of reevaluation to give due consideration to changing needs congruent with time. A criteria for optimum utilization of wetlands needs to be developed reflecting on the need for and of the potential use of the resource and for consideration of a mechanism for the resolution of conflicts. Towards this end, consideration should be given to the situation of wetlands in their natural state to provide for water storage, stabilization of runoff, erosion control, firebreaks, amenities, as a source of food and fiber, and as a haven for biota. On the other hand, consideration should be given to land drainage for satisfying the need for maintaining a viable agriculture, to facilitate construction and maintenance of roads, railroads, urban areas, airports, parks and recreational areas, and as an effective disease vector control device. In between the extremes is an area of water control and land management that accommodates intermediate needs for and use of the resource. It is this intermediate area, which encompasses the large sector of the economic and social spectrum of needs, which will pose the greater pressure for development of the resource, resulting in conflicts, and, of course, requiring a clearer and more definitive policy on the use and development of wetlands. (See Appendix U, Coastal and Estuarine Areas; Appendix J, Outdoor Recreation; Appendix O, Fish and Wildlife; and Appendix V, Health Aspects.)

FEDERAL AGENCY PARTICIPATION

There is no outstanding authority to single out land drainage as a major part of any Federal agency's responsibility. Most drainage activities are included in, and often subordinate to, other water and related land resources programs. Proper consideration and thorough resolution of drainage problems will require cooperation between all agency's and careful coordination of plans.

The major roles of the Department of Agriculture and the Department of the Army are covered in depth in the chapters relating to their areas of responsibility.

While the Department of the Interior has no direct responsibility in affecting land drainage programs, its responsibilities in regard to fish and wildlife, recreation, land management and water quality can be greatly affected by land drainage. Therefore, all land drainage projects must be closely coordinated with the Interior Department to assure that they do not adversely impact on programs relating to other water and related land development and management disciplines.

STATE PARTICIPATION

Many State agencies have varied interests which concern programs for land drainage. State-level review of land drainage proposals is of great significance, for it adds a new dimension to the analysis of the drainage function. Review from the State point of view reflects the implementation of Wetlands Acts recently enacted by some of the States and of similar legislation under consideration by other States. Almost all of this legislation is oriented towards increased preservation of wetlands, recognizing its intrinsic and varied multiple purpose values.

CHAPTER 2. AGRICULTURAL LAND DRAINAGE

Agricultural drainage may be defined as the removal of excess water from agricultural lands by engineering means. Agricultural drainage problems may be caused by excesses of surface water or subsurface water, or both. Surface drainage works remove water from the wet land, or divert or confine water so that it does not reach the protected area. Subsurface drainage is the removal of water from the soil profile, more specifically the removal of excess gravitational water from the major root zone. The purpose of agricultural drainage is to create an environment suitable for the maximum growth and production of plants. Drainage is the first step in the improvement of soils with excess water for agricultural use before other needed conservation practices may be applied successfully.

The material in this chapter is presented by the six NAR Sub-regions and 21 Areas delineated by the Coordinating Committee. Existing data, records, and reports were used wherever possible. County data were summed by groupings to approximate the 21 Areas.

PLANT ENVIRONMENT (3,4 & 5) 1/

Most crops grown in the NAR do not penetrate the water table. Root development is limited in soils with high water tables; consequently, plants lack the ability to mechanically support themselves and to gather nutrients including water.

Water that fills the soil pores displaces the air in the soil. This lack of soil aeration adversely affects the biological activities and chemical properties within the soil. Soil temperature, closely related to soil moisture and retention, affects length of growing season, absorption of nutrients, germination, and fruit ripening. Soil structure is affected by waterlogging. The aggregation of soil particles is slowed by reduced root and biotic activity. Tilth is destroyed by trampling livestock and by farming operations on wet soil. Wet spots in the field delay farm operations and prevent uniform treatment. Drainage of agricultural land enhances the environment of the root zone by affecting soil aeration, temperature, and structure.

SOILS WITH EXCESS WATER FOR AGRICULTURAL USE

Agricultural wet lands consist of soils upon and/or in which excess water limits the agricultural and forestry production capability. In the Conservation Needs Inventory (CNI), the basic soil data from sample areas in every county were interpreted in terms of the land classification. Major categories in this classification are unit, subclass and class.

1/ Numbers in parentheses refer to bibliographical references on pages J-62 and J-63.

Units are groups of soil that are adapted to the same kinds of lands, and that require similar management.

The land capability subclass is a grouping of units having similar kinds of limitations or hazards. Subclass "w" identifies soils where excess water is the dominant hazard or limitation in their use. Poor soil drainage, wetness, high water table, and overflow are the criteria for determining which soils belong in this subclass. (6)

The class category places the soils in eight land capability classes. The risks of soil damage, or the limitations in use become progressively greater from Class I to Class VIII. Lands in Class II and Class III are suitable for intensive cultivation with appropriate conservation treatment. Wetlands used for wildlife (2), are generally those in Classes IVw through VIIIw.

Land use by capability class and subclass were obtained from the CNI printout. The figures were updated to coincide with those in Appendix G, Land Use and Management (See Table J-1, Present Use of Soil with Wetness Hazard).

Land Capability Class and Subclass IIw and IIIw comprises soils with excess water problems that are suitable for intensive agricultural use when adequately treated (See Table J-2, Present Use of Wet Soil Suitable for Intensive Cultivation with Appropriate Treatment).

AGRICULTURAL WET LAND ADEQUATELY TREATED

Agricultural wet land is considered adequately drained when the drainage practices that are essential to its improvement have been applied. The median acreages treated as reported in the "Agricultural Conservation Program - Summary 1966" and State "Conservation Needs Inventory" are considered acreages adequately drained.

MEASURES

Conservation practices defined in the Soil Conservation Service National Catalog and applied amounts of these practices are printed in SCS accomplishment reports (See Table J-3, Drainage Practices Applied on Agricultural Lands). Amounts of tile, open ditch, surface drains, and drainage pumps installed are assumed necessary to have drained acreages adequately. Costs per practice unit were obtained from several agricultural agencies. Amounts, economic life, operation and maintenance, etc., were considered in calculating capital (one-time) and average annual cost per composite cropland acre (See Table J-4, Associated Capital Costs on Agricultural Lands). As forestry drainage is not now practiced, practice types and amounts can only be estimated. Measures would be less sophisticated than for cropland; cost per forest acre is assumed half that of cropland acre.

TABLE J-1
PRESENT USE OF SOIL WITH WETNESS HAZARD[1/]

Sub-region and Area	Crop-land	Grass-land	Forest	Other Land	Urban	Total "w" Soils[1/]
	1000 acres					
Sub-region A						
1	57	15	1048	11	-	1131
2	55	14	402	14	-	485
3	108	27	429	10	-	574
4	32	6	172	10	-	220
5	60	6	515	119	4	704
Subtotal A	312	68	2566	164	4	3114
Sub-region B						
6	44	6	340	51	3	444
7	35	9	225	48	7	324
8	156	56	292	88	11	603
9	39	17	348	102	8	514
10	68	49	254	70	7	448
Subtotal B	342	137	1459	359	36	2333
Sub-region C						
11	560	248	555	159	-	1522
12	278	187	584	200	10	1259
13	1	1	15	13	-	30
Subtotal C	839	436	1154	372	10	2801
Sub-region D						
14	56	22	178	68	21	345
15	328	128	576	333	5	1370
16	54	10	309	166	-	539
Subtotal D	438	160	1063	567	26	2254
Sub-region E						
17	528	346	657	221	-	1752
18	634	73	958	503	-	2168
Subtotal E	1162	419	1615	724	-	3920
Sub-region F						
19	257	159	617	128	-	1161
20	116	65	517	108	-	806
21	95	53	667	54	-	869
Subtotal F	468	277	1801	290	-	2836
NAR TOTAL	3561	1497	9658	2476	76	17268

1/ Wetness hazard is indicated in SCS Land Capability Subclass "w" - excess water in or on the surface. All Capability Classes are included.

TABLE J-2

PRESENT USE OF WET SOIL SUITABLE FOR INTENSIVE CULTIVATION WITH APPROPRIATE TREATMENT[1/]

Sub-region and Area	Crop-land	Grass-land	Forest	Other Land[2/]	Total "w" Soils[1/]
	1000 acres				
Sub-region A					
1	47	5	240	3	295
2	41	9	89	8	147
3	81	16	155	3	255
4	24	3	71	3	101
5	45	3	206	5	259
Subtotal A	238	36	761	22	1,057
Sub-region B					
6	27	3	105	18	153
7	23	4	36	6	69
8	125	31	95	28	279
9	16	7	46	11	80
10	53	20	42	20	135
Subtotal B	244	65	324	83	716
Sub-region C					
11	414	137	326	63	940
12	200	83	242	84	609
13	1	-	3	5	9
Subtotal C	615	220	571	152	1,558
Sub-region D					
14	51	12	84	41	188
15	285	81	371	120	857
16	49	7	223	10	289
Subtotal D	385	100	678	171	1,334
Sub-region E					
17	454	218	382	148	1,202
18	609	38	770	71	1,488
Subtotal E	1,063	256	1,152	219	2,690
Sub-region F					
19	215	107	429	62	813
20	100	40	326	29	495
21	89	38	435	14	576
Subtotal F	404	185	1,190	105	1,884
NAR TOTAL	2,949	862	4,676	752	9,239

1/ Acreages of Land Capability Class and Subclass IIw and IIIw listed in the 1959 Conservation Needs Inventory updated to 1963.

2/ The 52,000 urban acres are not available for conversion to agricultural land and therefore are not included.

TABLE J-3
DRAINAGE PRACTICES APPLIED
ON AGRICULTURAL LANDS

Sub-region and Area	Practices 1/				Treatment 2/	
	Tile Miles	Open Ditch Miles	Surface Drains Miles	Pumping Plants No.	Installation Costs $1000	Adequately Treated 1000 acres
Sub-region A						
1	213	1*	225	-		
2	24	10	42	29		
3	21	2	33	5		
4	35	2	71	-		
5	11	1	44	-		
Subtotal A	304	15	415	34	1,390	57
Sub-region B						
6	95	52	96	-		
7	100	456	10	-		
8	146	226	23	2		
9	82	371	15	23		
10	101	186	1*	-		
Subtotal B	524	1,291	144	25	5,665	88
Sub-region C						
11	341	925	245	-		
12	588	582	29	7		
13	1*	4	1*	-		
Subtotal C	929	1,511	274	7	7,896	204
Sub-region D						
14	237	137	18	1		
15	1,045	2,033	404	1		
16	212	259	4	1		
Subtotal D	1,494	2,429	426	3	8,569	146
Sub-region E						
17	2,218	790	268	6		
18	591	4,417	435	7		
Subtotal E	2,809	5,207	703	13	24,401	531
Sub-region F						
19	1,170	779	595	-		
20	368	641	248	-		
21	422	2,158	604	-		
Subtotal F	1,960	3,578	1,447	-	13,373	204
NAR TOTAL	8,020	14,031	3,409	82	61,294	1,230

* Less than 1 is not included in total. Price base 1966.

1/ Amounts printed in SCS accomplishment reports.

2/ Median of farmland normally devoted to crops - ACP 1966 summary and "w" cropland reported adequately treated in the CNI (see p. J-9).

TABLE J-4
ASSOCIATED CAPITAL COSTS
ON AGRICULTURAL LANDS

Evaluation Item	Tile	Open Ditch	Surface Drain	Pump	Total
		NORTH ATLANTIC REGION			
Amount (unit/acre)	34.4 ft.	60.2 ft.	14.6 ft.	.000067ft.	
One Time Cost ($/acre)	15.72	31.51	2.43	.17	49.83
Economic Life (years)	30.	15.	10.	20.	
Interest Rate (Percent)	6.	6.	6.	6.	
Installation Cost ($/acre/year)	1.14	3.24	.33	.01	4.72
Oper. & Maint. Cost ($/acre/year)	.15	.64	.12	.01	.92
Average Annual Cost ($/acre/year)	1.29	3.88	.45	.02	5.64
		SUB-REGION A			
Amount	28.2 ft.	1.4 ft.	38.4 ft.	.0006 ft.	
One Time Cost	19.70	.41	2.69	1.50	24.30
Average Annual	1.65	.05	.49	.26	2.45
		SUB-REGION B			
Amount	31.4 ft.	77.4 ft.	8.6 ft.	.0003 ft.	
One Time Cost	26.10	37.18	.60	.71	64.59
Average Annual	2.18	4.59	.11	.12	7.00
		SUB-REGION C			
Amount	24.0 ft.	39.1 ft.	7.1 ft.	.00003 ft.	
One Time Cost	13.22	24.64	.99	.09	38.94
Average Annual	1.10	3.04	.18	.02	4.34
		SUB-REGION D			
Amount	54.0 ft.	87.8 ft.	15.4 ft.	.00002 ft.	
One Time Cost	22.15	32.50	3.54	.05	58.24
Average Annual	1.85	4.02	.65	.01	6.53
		SUB-REGION E			
Amount	27.9 ft.	51.8 ft.	7.0 ft.	.00002 ft.	
One Time Cost	10.96	33.14	1.54	.06	45.70
Average Annual	0.92	4.09	.28	.01	5.30
		SUB-REGION F			
Amount	50.7 ft.	92.6 ft.	37.5 ft.	.0	
One Time Cost	19.78	39.82	5.99	.0	65.59
Average Annual	1.65	4.92	1.10	.0	7.67

Price base 1966.
Units per acre are based upon practices, installation costs, and adequately treated acres presented in Table J-3.

NEEDS

Following is the rationale which was used in the development of the Area Summaries for plan formulation. Cropland needing drainage is cropland requiring treatment minus the acreage already adequately treated. Cropland on IIw and IIIw land requires treatment for optimum production. Forest needing drainage is IIw through IVw lands of types believed profitable to drain (See Table J-5, Forest Land Needing Drainage). Quantities demanded 1/ vary with the objective considered.

Toward the National Efficiency Objective (NE), 80% of the cropland needing drainage is expected to be treated. Experience has shown that about 20% of the possible benefactors do not participate. With a continuance of the going rate of treatment, acreage drained by 1980 would be 133% of what is now adequately drained, an additional 80% by 2000, and all of that expected by 2020. Forest land drainage could be expected to be 5% of forest needing drainage by 2000, and increase to 15% by 2020.

NE benefits of increased production, lowered production cost, and improved product quality are reflected in higher farm income. Benefit cost ratios range from 1:1 to more than 4:1; 2:1 was used for 80% and 1:1 for remaining acreages needing drainage.

Toward the Regional Development Objective (RD), it is assumed that all of the cropland needing drainage would receive treatment as soon as possible with the available resources and lead time. Thus, acreage drained by 1980 would be 150% of what is now adequately drained, an additional 100% by 2000, and all of the cropland needing drainage by 2020. It is further assumed that forest land would be drained at a faster rate under this RD than under NE; 5% by 1980, 15% by 2000, and 45% by 2020.

RD benefits that result from increased spending by project beneficiaries (multiplier income) are estimated to be 20% of NE

1/ Much of the drainage work in progress is to replace obsolete systems and to upgrade existing works and are not accounted for in the quantities demanded.

TABLE J-5
FOREST LAND NEEDING DRAINAGE

Sub-region and Area	Forest Land Feasible to Drain (Class IIw, IIIw, IVw)	Practicability by Forest Type: Practical: Maple Beech Birch	Practical: Spruce Fir	Practical: Aspen Birch	Practical: Lob-lolly Short-leaf Pine	Not Practical: Oak Gum Cypress	Improbable 1/
	1000 acres						
Sub-region A							
Area 1	289	87	187	15	-	-	-
Area 2	183	37	137	9	-	-	-
Area 3	322	112	194	16	-	-	-
Area 4	101	41	60	-	-	-	-
Area 5	318	66	235	17	-	-	-
Subtotal A	1,213	343	813	57	-	-	-
Sub-region B							
Area 6	196	99	-	-	-	-	99
Area 7	67	17	-	-	-	-	50
Area 8	145	72	29	-	-	-	44
Area 9	124	2	-	2	6	-	114
Area 10	137	13	-	-	-	-	124
Subtotal B	671	203	29	2	6	-	431
Sub-region C							
Area 11	402	199	40	40	-	-	123
Area 12	390	215	-	19	-	-	156
Area 13	2	-	-	-	1	-	1
Subtotal C	794	414	40	59	1	-	280
Sub-region D							
Area 14	109	-	-	-	-	-	109
Area 15	420	126	-	-	-	3	291
Area 16	223	-	-	-	168	-	55
Subtotal D	752	126	-	-	168	3	435
Sub-region E							
Area 17	595	149	-	-	-	-	446
Area 18	770	-	-	-	231	77	462
Subtotal E	1,365	149	-	-	231	77	908
Sub-region F							
Area 19	470	-	-	-	94	14	362
Area 20	338	-	-	-	322	6	10
Area 21	460	-	-	-	300	46	114
Subtotal F	1,268	-	-	-	716	66	486
NAR TOTAL	6,063	1,235	882	118	1,122	146	2,560

1/ Drainage appears improbable on four forest types: Oak-Hickory, White-Red-Jack Pine, Elm-Ash-Cottonwood, Oak-Pine.

benefits.1/ Otherwise underutilized and attracted resources used in construction and operation are estimated at 40% of the average annual cost.2/ Up to 100% of the NE benefits may be added, depending on charges imposed on users.3/

Toward the Environmental Quality Objective (EQ), the cropland needs may be the same as RD; this assumes open space farmland is visually and culturally desirable. Forest land drainage may provide both EQ advantages and disadvantages; because the net effect may be neutral, forest land needs for EQ are considered the same as NE.

EQ benefits, although not measured monetarily, could be expressed as the percentage of land area on which maintenance of agricultural open space is encouraged by drainage.

1/ Increased spending arises from new demands upon transportation, processing, and marketing industries, from additional materials and services required to increase production, and from expenditures of rural suppliers of goods and services. Field experience has shown the 20% benefit to be a reasonable estimate; it has been frequently used in project evaluations.

2/ The amortized cost comprises 80% and the operation and maintenance cost 20% of the average annual cost. Local labor, equipment, and materials are used for one-fourth of the installation and all of the operation and maintenance of drainage works. The 40% benefit assumes local resources are underutilized.

3/ Project benefits minus costs from within the region are regional development benefits. The costs borne outside the region would be included as RD benefits.

REGIONAL SUMMARY

Excess water exists on 17.2 of the 105.7 million land acres in the North Atlantic Region. Approximately 9.6 million acres of these "w" soils are in forest, 5.1 in crop and pasture, and 2.5 million acres in other land.

PRODUCTION

Food Crop Production

Farmers in the NAR cultivate 3,560,000 acres of land classified as "w" soil. They have applied measures to adequately drain 1,230,000 cropland acres. With adequate drainage, yields on an additional 1,720,000 of these acres could be increased from 10 to more than 50%. Corn yields average 51 bushels per acre on fields with fair drainage, 60 bushels per acre with good drainage, and 67 bushels per acre with excellent drainage. From Public Law 566 Work Plans in NAR the average estimated hay yields per acre increased from 1.5 tons without drainage to 2.9 tons with drainage. Yields of small grain, soybeans, potatoes, vegetables, tobacco, and most nursery crops would increase by similar percentages.

Quality of product is usually higher from well drained fields. A clear relationship exists between orchard condition, size and quality of yield and drainage behavior; the orchards being poorest where shallow rooting is induced by a high water table. (7) Researchers reported from New York State that a high water table often results in poor fruit and weak growth. (8) A low soil moisture content in late August through September is apparently a prerequisite to quality in honeydew melons. (9) The seed viability of barley and oats was reduced at a high water table level. (10) Mown hay can be bailed sooner on well drained fields; lessened exposure to the elements reduces the chance of food value loss. A high water table during the growing season may result in a shift to inferior quality composition of the grass. The raw protein yield was from 10 to 25 percent higher at a lower depth of water table. (11) Eden (1951) reported the crude protein yield of ryegrass increased from 497 pounds per acre with a high water table (14 to 16 inches) to 1,318 pounds at the medium (20 to 26-1/2 inches) and to 1,513 pounds at the low water table (30 to 41 inches). Quality deterioration during maturation is caused by parasitic attacks on poorly drained lands. Weed infestations, disease and difficulty in operating the land and harvesting crops result in lowered quality of product. Improved food value and/or reduced food value losses, resulting from drainage, are product quality benefits.

Tillage operational costs may be reduced as a result of need for less power to till the improved soil, reduced time to cover an area, elimination of replanting, improved machinery, and mobility and timeliness of operation.

Drainage often results in the opportunity to use the land more intensively. (12) The farm may profit from better rotations and increased use and efficiency of fertilizer. With drainage, it may be feasible to cultivate land that has never been cultivated in the past. Reallocation of resources used in production may be profitable. Shifts of crops, changes in types of farming, etc., make possible new alternative uses and intensity of use to the land operator.

Timber Production

Drainage or water regulation of forest wetland in the United States is relatively new, dating back only to the early 1900s. In contrast, wetland drainage in Europe and Asis dates back to the 17th Century. (13) More important and extensive works, however, have been carried on during the last 100 years. European forest wetland conversion encompasses many phases of research similar to the silvical and forest management studies carried on in the United States. The most important point stressed is the extreme care used in selecting sites for conversion. Wetland research in the United States indicates a potential for forest land water regulation in regard to the establishment and production of forest tree species.

In regard to northern tree species, two- to four-fold acceleration in the growth of arborvitae followed shallow drainage of a Northern Michigan bog. (14) In Minnesota and Wisconsin, cubic volume of hardwoods, cedar, black spruce, and tamarack made phenomenal increases (51 to 563%) after draining. (15) Removal of excess water from bogs has an immediate beneficial effect on black spruce saplings and a similar, but delayed, effect on balsam fir. (16) The growth is indicative of what proper drainage can accomplish in the Spruce-Fir Type forest wetlands.

Southern coniferous tree species may also benefit by the removal of excess water. Maki(17) observing loblolly pine on drained and poorly drained land in North Carolina, found that after 17 years, drainage was reflected in more than double height growth, a 14-fold increase in yield per acre, and almost double average diameter. Schlaudt(18) reports a doubling in growth of slash pine in response to drainage. Graham and Rebuck(19) reported marked differences in the establishment and growth of pond pine on a formerly pocosin (swampy) area in response to drainage conditions. They conclude that such sites might be managed for the production of pond pine, Atlantic white cedar or swamp gum, and indicate that swamp gum will constitute an important successor to pine in the drier site under existing conditions of drainage. Research conducted in the Loblolly-Shortleaf Pine type indicates a potential for increasing growth through water regulation.

In the southeast, the bottomlands are considered among the most productive for hardwood timber and wildlife because of their inherent fertility and abundant moisture. Indications are that these

areas (Oak-Gum-Cypress) should not be drained. Water management in these areas is aimed at maintaining natural water levels. (20) Uncontrolled drainage may produce environmental changes which preclude continued production of prime hardwoods on bottomland sites. "Good bottomland species suitable for sawlog and veneer will yield greater return than slash pine established after draining." (21) "Drainage to convert prime hardwood land to pine production is largely a thing of the past because of the rise in demand for hardwood timber and fiber." "Occasionally, lands too wet for timber production can be improved by controlled drainage. Surface drainage of ponded water has resulted in the invasion of hardwood and cypress into open swamps. Furthermore, soil-water conditions at the wet extreme of tolerance for hardwoods have been improved by limited drainage. However, because of limited information on the effects of water levels modification on hardwoods (Oak-Gum-Cypress), controlled drainage practices cannot be prescribed on sites capable of sustaining hardwoods." (22)

For the remaining six major forest types, the dominant tree species are evaluated in regard to their habitat requirements. Water retention on hickory bottomlands and removal of excess water from wetter oak sites would favor species of the oak-hickory type. Water management on the Maple-Beech-Birch type would be expected to provide optimum habitat for the three major component species. Water regulation for White-Red-Jack pine type would appear improbable. Water management in the Aspen-Birch type would favor the more economically important tree species by developing a well drained soil habitat. Since a large percentage of the Elm-Ash-Cottonwood type is within active residential development, no water regulation from a forestry standpoint is advisable. Species in the Oak-Pine type are found in the Oak-Hickory and Loblolly-Shortleaf Pine types.

Research data and tree habitat requirements indicate a potential for increasing growth through water regulation in the Spruce-Fir, Loblolly-Shortleaf Pine, Beech-Birch-Maple and Aspen-Birch Forest types. No drainage measures are recommended on Oak-Gum-Cypress Forest Type. Water regulation on the Oak-Hickory, White-Red-Jack Pine, Elm-Ash-Cottonwood, and Oak-Pine other four types is improbable or questionable.

DRAINAGE DESIGN CRITERIA AND MEASURES

Drainage Design Criteria (5)

Soil Conservation Service Drainage Design Criteria have been developed from empirical methods. The required capacity of closed subsurface drains (tile) and open ditches are determined through the application of drainage coefficients. A drainage coefficient is that rate of water removal per unit of area used in drainage design to protect crops from excess surface and subsurface water. Drainage coefficients in the NAR have been developed through some 50 years of

measuring flow in drainage systems and observing the influence of their capacities on various crops. They have been checked in many states over complete 20 year life cycles of many drainage systems.

Drainage coefficients are selected with respect to the degree of protection to be provided for various crops. Several degree of protection are recognized corresponding to the crop tolerance to excess water. For example, degrees of protection may be set for crops in a descending order as follows: Truck and specialty crops, general field crops, improved pasture and forest or native range. Rainfall frequency, intensity and duration, climate, soil permeability, crops to be grown and the size of area to be drained are all considered in selecting drainage coefficients. It may be expressed in terms of the equivalent inches of water removed in 24 hours, or in terms of flow rate per unit of area. Curves showing the variation of the rate with the size of the drainage area commonly are used.

Figure J-2, Tile Drainage Chart, was used in determining the capacity of subsurface drains. In order to use the chart, it is necessary to know the depth of water in inches to be romoved in 24 hours from the watershed contributing to the tile. The drainage coefficient in the NAR varies from one-eighth of an inch to one inch per day. They vary with local conditions and are specified in SCS state drainage guides.

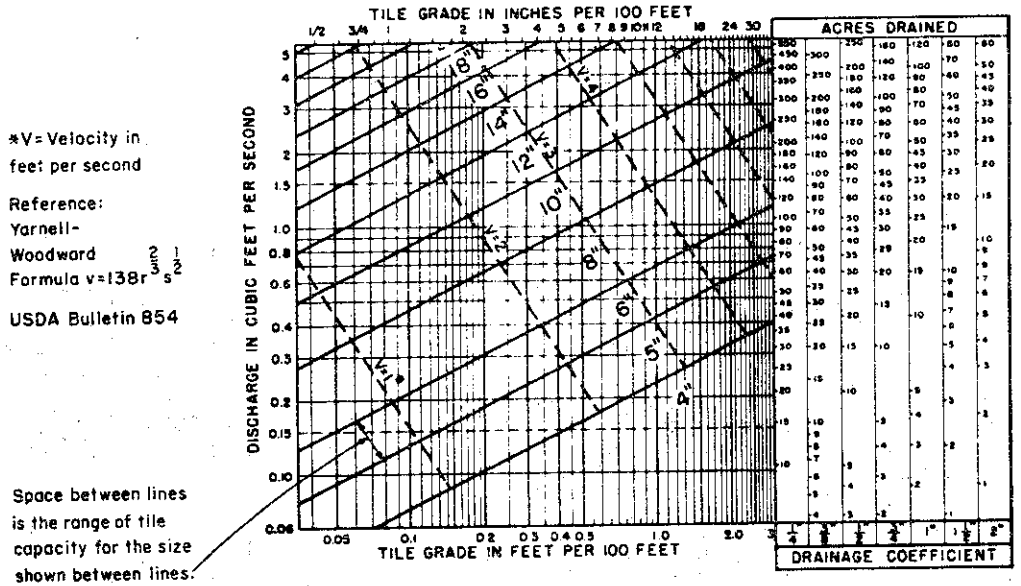
A series of drainage curves to compute capacities of open ditches have been developed for use in the NAR. Figure J-3 Drainage Coefficient Curves for Northern Humid Areas covers the entire NAR except the Virginia coastal plain, where a slightly higher requirement applies. The "C" curve is the basis curve for agricultural drainage and provides good drainage for corn, grain crops and rotation crops for average slopes of less than 25 feet per mile. The "D" curve should be used to provide drainage for pasture in areas, while the "C" curve is the basic drainage curve for general crops. The "B" curve applies to drainage of truck crops, nursery crops and other crops that cannot stand much flooding without high damages. The "A" curve is used to give overflow protection to highly specialized crops.

Drainage Measures

Tile or closed drains are clay, concrete or plastic pipe installed beneath the surface with a planned grade. Over 8,000 miles of farm tile drain are operative in the NAR (See Table J-3, p. J-12). The scarcity of contractors, smaller size jobs, distance from tile kilns, and stonier soils make installation costs higher in New England. The cost per linear foot varies depending on the tile size and the installation costs. Since the practical size and, consequently, the capacity is limited, most tile are "on farm" installations. Laterals carry the excess field water to mains.

FIGURE J-2

TILE DRAINAGE CHART (ACRES DRAINED BY VARIOUS SIZES OF TILE)



*V= Velocity in feet per second

Reference:
Yarnell-Woodward Formula $v=1.38r^{\frac{2}{3}}s^{\frac{1}{2}}$

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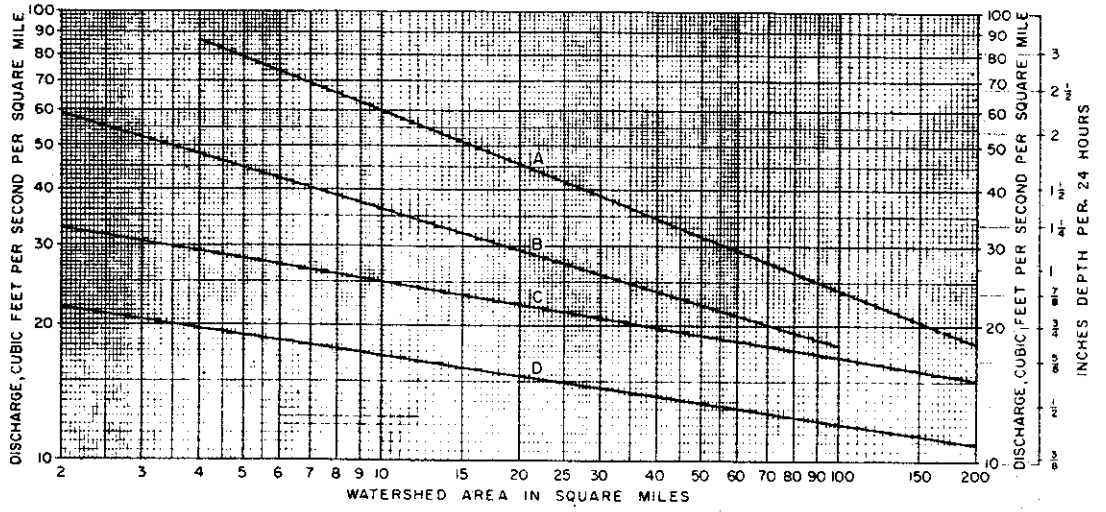
Space between lines is the range of tile capacity for the size shown between lines.

FIGURE J-3

DRAINAGE COEFFICIENT CURVES FOR NORTHERN HUMID AREAS



USE OF CURVES FOR NORTHERN HUMID AREAS

Curve A — For good protection from overflow (not maximum flood runoff)
Curve B — For excellent drainage
Curve C — For good agricultural drainage; basic drainage curve for grain crops
Curve D — For fair agricultural drainage and drainage improved pastures

Watershed area to be determined above each section of the ditch for which capacity is to be computed. Applicable only to flat watershed areas having average slope less than 25 feet per mile.

REFERENCE
These curves, developed by John G Sutton, were published in the article, "Hydraulics of Open Ditches," Agr. Eng., vol. 20, no. 5, May 1939

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION DRAINAGE SECTION

STANDARD DWG NO
ES- 701
SHEET of
DATE 11-30-54

Open drainage ditches are constructed to provide free outlets to mains, subsurface drainage (tile), and with sufficient capacity to remove storm surface waters. The 14,000 miles of drainage ditches vary from smaller collection ditches of 25 square feet end area to large basin outlets. Outlet ditches have relatively steep side slopes and are not crossable by farm machinery. These channels are the major project type drainage practice.

Surface drains, usually constructed with flat side slopes for ease of crossing, collect water within a field. The 3,400 miles of installed surface drains (See Table J-3 p. J-12), exclude vegetated waterways and diversion terraces. These field drainage ditches are particularly needed on heavy soils and on pocketed areas. This drainage measure is generally an on-farm practice.

Pumping facilities are installed for removing excess surface or ground water from lowlands where there is no gravity outlet. There are 82 pumping plants in the NAR (Table J-3, p. J-12). Although the pumping plant is more commonly an on-farm associated cost, it often involves a number of landowners and, therefore, is a project practice.

Vegetative measures are not generally considered as drainage practices. However, conservation cropping systems, crop residue use, grasses and legumes in rotation, cover and green manure crops, etc., are practices that protect and improve the soil structure. Subsequently, the improved tilth allows water to soak into the soil and percolate more deeply.

On-farm costs required with drainage facilities are considered as associated costs. Since the maintenance of most vegetative measures recur annually, the cost is considered as a farm production cost. Mechanical practices generally have an economic life of more than ten years and are considered as capital costs. The average annual associated capital cost for an NAR composite acre drained is $5.64. The calculation is shown in Table J-4 (p. J-13). This cost varies from $2.45 in Sub-region A to $7.67 in Sub-region F.

Practicality

Benefits occur as an increased agricultural income "with" the project as compared to "without" the project. These on-site benefits may include: Land use changes, more intensive use, reduced production costs, and improved resource allocation. Analyses of farm budgets show $3 to $58 increases of net income/acre/year resulting from drainage. A comparison of the net income to the project, induced, and associated costs is made to determine practicability.

Because of the wide differences of farm incomes, of the wetness problem, and of extent practices are applied, an attempt was not made to determine a composite farm income "with" and "without" drainage.

It should be pointed out that small gross farm income increases may substantially improve the farm family net income Let's say, for illustration, that production value is $66 and production cost is $62 without drainage. With drainage, the production value is $87 and production cost, including the associated cost, is $71. Thus, in our illustration, the net farm income has increased from $4 to $16; the farm family has four time the expendable income as a result of drainage.

Solutions to drainage problems often extend beyond the farm boundary. Group action is required to implement drainage projects. Several landowners often mutually carry out small group enterprises. Larger drainage projects generally require more formal organization; legal subdivisions of State government such as municipal, township and county or special drainage districts (as Meadow Companies in New Jersey tidal areas), carry out most of these larger enterprises. The number of larger drainage projects is shown in Table J-6, Drainage Projects of Agricultural Lands. More than a million dollars of annual primary drainage benefits will be realized when Public Law 566 approved work plans are completed, as shown in Table J-7, Drainage in Watershed Work Plans.

EFFECTS OF DRAINAGE

Effects on Fish and Wildlife(23)

Fish and wildlife resources are affected by drainage measures in various ways and combinations. Inter- and intra-species changes may occur. For example, in a Vermont open drainage lateral running through an alder thicket, numerous black ducks were observed feeding in the ditch where no open water formerly occurred. Waterfowl broods have been observed in ditches in New York. Brook trout reproduction was seen in field drains in New Hampshire. In many coastal bottomlands, main drains serve the same function as level ditches installed for wildlife habitat.

Channelization and drainage projects may have adverse effects on fish and wildlife. In these instances, alternative practices should be carefully evaluated. Some of these alternatives are channel relocation, selective clearing and snagging, one-side channel excavation, notched ledges, stacking and planting spoil, and selection of wildlife plant species. Where adverse conditions still remain, feasible mitigation measures should be applied to compensate for the losses.

The impact on fish and wildlife resources must be carefully studied. Even though there are objections to damages of a particular type of species, the drainage project may be beneficial to the gross fish and wildlife resource. The "edge effect" of ditches and associated field border growth is partially responsible for pheasant and

TABLE J-6

DRAINAGE PROJECTS OF AGRICULTURAL LANDS

Area	Areas drained and used for agriculture						Cost of Drainage Work and Services				Constructed, Enlarged or Installed			Type of Organization		
	before 1950		1950-1959		by 1960		1950-1959		Total		1950-1959			Land-owner	Coop.or Mutual	Legal
	Project	1000 Acres	Project	1000 Acres	Project	1000 Acres	Project	1000 Dollars	Project	1000 Dollars	Open Ditches Miles	Tile Miles	Other Miles	Number of Projects		
11	-	-	1	1	1	1	-	-	-	-	-	-	-	1	-	-
12	3	20	-	-	3	20	-	-	1	36	-	-	-	-	1	2
14	1	1/	5	5	6	5	6	34	6	34	11.0	4.0	-	-	6	-
15	5	129	3	9	8	137	3	106	7	116	45.6	-	-	-	2	6
16	3	3	1	1/	4	3	-	6	3	6	2.6	1.0	-	-	4	-
17	3	10	-	-	3	10	-	-	1	14	-	-	-	-	2	1
18	170	553	32	53	202	559	59	741	74	829	315.2	-	2	-	12	190
21	10	22	5	17	15	39	5	41	12	64	22.6	-	-	5	8	2
NAR TOTAL	195	737	47	85	242	774	73	928	104	1099	397.0	5.0	2	6	35	201

Source of data: U. S. Census of Agriculture 1959, Drainage of Agricultural Lands
U. S. Department of Commerce, Bureau of the Census

1/ Less than 500

TABLE J-7

DRAINAGE IN WATERSHED WORK PLANS

Sub-regions	PL - 566 Work Plans No.	Drainage Benefits $1,000
A & B New England	22	9
C & D Delaware, Hudson & Lake Champlain	21	459
E & F Chesapeake	33	603
NAR TOTAL	76	1,071

Data from PL-566 watershed work plans approved for operations, June 30, 1966

non-game bird increases. Although drainage and land clearing have resulted in extension of cropland into wooded, brushy or grassy areas, net cropland declines have resulted in increased grass and wooded wildlife habitat.

Further resource enhancements are often possible by incorporating features or measures into the drainage plan. Some of these are fishways or ladders, modified channel shapes and designs, inflatable dams, side channels or lagoons, stream improvements, ditchbank plantings, and the previously listed alternative measures.

Wetland Wildlife Development

Some wildlife enthusiasts fear that drainage always endangers "wetland". Many of the wet soils needing drainage occur on hilltops and sloping land of irregular topography; these are not "wetlands" in terms ordinarily used by wildlife professionals and laymen. Evidence of the relatively minor nature of agricultural drainage is drawn from resurveys of coastal wetland by the Bureau of Sport Fisheries and Wildlife. None of the "wetland" loss in the NAR from 1954 to 1964 was attributed to agricultural drainage. However, more recent surveys suggest that some losses to wetland habitat of varying ecological significance have been recorded due to drainage problems in some locations in the NAR.

Wildlife wetland is being preserved and/or developed by both public and private interests. Landowners, provided with technical assistance, are retaining existing wetland wildlife habitat by decreasing agronomic, forestry or husbandry uses and applying necessary maintenance measures to 289,226 acres. Wildlife wetlands have been developed on 62,653 acres by creating or improving wetlands habitat by diking, ditching, planting or other means. About a third of the present Public Law 566 projects have planned fish or wildlife developments. These ponds and marshes are used for beautification, nature study and observation, nature photography, biological research, and aviary collections in addition to hunting and trapping pursuits. The potential of drainage and water control for new or improved fish and wildlife environment is considerably greater than is being realized. A reasonable goal would appear to be one where at least 50 to 75% of the public projects include fish or wildlife enhancements.

Effects on Cultural Values

Historical or prehistoric sites may be disrupted, or revealed, or otherwise endangered by the drainage of wetlands and drainage of such lands may expose evidence of paleontological interest. Archeological and paleontological evidence is covered by the Antiquities Act of 1906 and subsequent legislation to the Historic Sites Act of 1966.

AGRICULTURAL LAND DRAINAGE SUMMARIES

Agriculture land drainage summaries for the Region, the six Sub-regions and the 21 areas are included in Tables J-8 through J-35, which follow on pages J-29 through J-56.

TABLE J-8
AGRICULTURAL LAND DRAINAGE SUMMARY
NORTH ATLANTIC REGION

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	1229	0	1229	61100	6985			
NATIONAL EFFICIENCY									
	1980	373	0	373	18515	2114	4228	1693	
	2000	761	168	929	41135	4679	9358	3741	
	2020	241	503	744	20489	2367	4634	1852	
REGIONAL DEVELOPMENT									
	1980	617	168	785	34311	3916	6444	2851 to 9295	
	2000	861	503	1364	53217	6040	9968	4410 to 14378	
	2020	241	1510	1751	42056	4777	7884	3489 to 11373	
ENVIRONMENTAL QUALITY									
	1980	617	0	617	30634	3502	5781	2579 to 8410	
	2000	861	168	1029	45864	5204	8589	3801 to 12290	
	2020	241	503	744	19978	2258	3727	1650 to 5377	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-9
AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION A

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	57	0	57	1385	160			
NATIONAL EFFICIENCY									
	1980	19	0	19	462	53	106		43
	2000	46	0	106	1847	211	422		169
	2020	80	181	261	4142	475	950		381
REGIONAL DEVELOPMENT									
	1980	30	60	90	1458	165	252	112 to	364
	2000	57	181	238	3584	408	674	298 to	972
	2020	94	545	639	9027	1029	1698	750 to	2448
ENVIRONMENTAL QUALITY									
	1980	30	0	30	730	84	140	62 to	202
	2000	57	60	117	2114	243	402	179 to	581
	2020	94	181	275	4483	512	845	374 to	1219

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-10
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 1. ST. JOHN RIVER BASIN

Wetlands comprise 24% of Area 1's 4,710,000 acres. There are 47,000 acres of Class IIw and IIIw Cropland and 289,000 acres of Class IIw, IIIw and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural demands are important in considering investment toward all three objectives.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/: (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	11	0	11	267	27			
NATIONAL EFFICIENCY									
	1980	4	0	4	97	10	20	8	.08
	2000	9	14	23	389	39	78	31	.19
	2020	16	43	59	911	92	184	74	.34
REGIONAL DEVELOPMENT									
	1980	6	14	20	316	32	32	14 to 46	.13
	2000	11	43	54	790	80	132	58 to 190	.23
	2020	19	130	149	2041	206	340	150 to 490	.40
ENVIRONMENTAL QUALITY									
	1980	6	0	6	146	15	25	11 to 36	.13
	2000	11	14	25	437	44	73	32 to 105	.23
	2020	19	43	62	984	99	163	72 to 235	.40

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-11
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 2. PENOBSCOT RIVER BASIN

Wetlands comprise 9% of Area 2's 5,456,000 acres. There are 41,000 acres of Class IIw and IIIw Cropland and 183,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Opportunities toward all three objectives are limited.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	10	0	10	243	24			
NATIONAL EFFICIENCY									
	1980	3	0	3	73	7	14	6	.05
	2000	8	9	17	304	31	62	25	.15
	2020	14	27	41	668	67	134	54	.26
REGIONAL DEVELOPMENT									
	1980	5	9	14	231	23	38	17 to 55	.09
	2000	10	27	37	571	58	96	43 to 139	.18
	2020	16	82	98	1385	140	231	102 to 333	.29
ENVIRONMENTAL QUALITY									
	1980	5	0	5	122	12	20	9 to 29	.09
	2000	10	9	19	352	36	59	26 to 85	.18
	2020	16	27	43	717	72	119	53 to 172	.29

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-12
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 3. KENNEBEC RIVER BASIN

Wetlands comprise 15% of Area 3's 3,757,000 acres. There are 81,000 acres of Class IIw and IIIw Cropland and 322,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural demands are important in considering investments toward all three objectives.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	19	0	19	462	67			
NATIONAL EFFICIENCY									
	1980	6	0	6	146	21	42	17	.16
	2000	15	16	31	559	81	162	65	.40
	2020	29	48	77	1288	187	374	150	.77
REGIONAL DEVELOPMENT									
	1980	10	16	26	437	63	104	46 to 150	.27
	2000	19	48	67	1045	151	249	110 to 359	.51
	2020	33	145	178	2685	389	642	284 to 926	.88
ENVIRONMENTAL QUALITY									
	1980	10	0	10	243	35	58	26 to 84	.27
	2000	19	16	35	656	95	157	70 to 227	.51
	2020	33	48	81	1385	201	332	147 to 479	.88

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-13
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 4. ANDROSCOGGIN RIVER BASIN

Wetlands comprise 10% of Area 4's 2,208,000 acres. There are 24,000 acres of Class IIw and IIIw Cropland and 101,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Opportunities toward RD and EQ are limited.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	6	0	6	146	15			
NATIONAL EFFICIENCY									
	1980	2	0	2	49	5	10	4	.09
	2000	5	5	10	182	18	36	14	.23
	2020	7	15	22	352	36	72	29	.32
REGIONAL DEVELOPMENT									
	1980	3	5	8	134	13	22	10 to 32	.14
	2000	6	15	21	328	33	55	24 to 79	.27
	2020	9	45	54	765	77	127	56 to 183	.41
ENVIRONMENTAL QUALITY									
	1980	3	0	3	73	7	12	5 to 17	.14
	2000	6	5	11	207	21	35	16 to 51	.27
	2020	9	15	24	401	40	66	29 to 95	.41

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-14
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 5. MAINE COASTAL BASINS

Wetlands comprise 18% of Area 5's 3,988,000 acres. There are 45,000 acres of Class IIw and IIIw Cropland and 318,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: EQ and RD. Agricultural demands intended to encourage and preserve rural areas should be fulfilled.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	11	0	11	267	27			
NATIONAL EFFICIENCY									
	1980	4	0	4	97	10	20	8	.10
	2000	9	16	25	413	42	84	34	.23
	2020	14	48	62	923	93	186	74	.35
REGIONAL DEVELOPMENT									
	1980	6	16	22	340	34	56	25 to 81	.15
	2000	11	48	59	850	86	142	63 to 205	.28
	2020	17	143	160	2151	217	358	158 to 516	.43
ENVIRONMENTAL QUALITY									
	1980	6	0	6	146	15	25	11 to 36	.15
	2000	11	16	27	462	47	78	35 to 113	.28
	2020	17	48	65	996	100	165	73 to 238	.43

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-15
AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION B

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	88	0	88	5685	616			
NATIONAL EFFICIENCY									
	1980	28	0	28	1809	196	392	157	
	2000	70	13	83	4941	536	1072	428	
	2020	27	37	64	2938	369	638	254	
REGIONAL DEVELOPMENT									
	1980	44	13	57	3262	352	582	258 to 840	
	2000	88	37	125	6879	745	1229	544 to 1773	
	2020	24	108	132	5037	547	903	401 to 1304	
ENVIRONMENTAL QUALITY									
	1980	44	0	44	2842	308	509	226 to 735	
	2000	88	13	101	6104	662	1092	483 to 1575	
	2020	24	37	61	2746	297	490	217 to 707	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-16
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 6. SOUTHERN MAINE AND COASTAL NEW HAMPSHIRE

Wetlands comprise 16% of Area 6's 2,692,000 acres. There are 27,000 acres of Class IIw and IIIw Cropland and 99,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: EQ. Preservation and encouragement of agricultural areas should be undertaken.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	10	0	10	646	70			
NATIONAL EFFICIENCY									
	1980	3	0	3	194	21	42	17	.11
	2000	8	5	13	678	74	148	59	.30
	2020	3	15	18	678	74	148	59	.11
REGIONAL DEVELOPMENT									
	1980	5	5	10	484	52	86	38 to 124	.19
	2000	10	15	25	1130	122	201	89 to 290	.37
	2020	2	45	47	1582	172	284	126 to 410	.07
ENVIRONMENTAL QUALITY									
	1980	5	0	5	323	35	58	26 to 84	.19
	2000	10	5	15	807	88	145	64 to 209	.37
	2020	2	15	17	614	66	109	48 to 157	.07

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-17
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 7. MERRIMACK RIVER BASIN

Wetlands comprise 10% of Area 7's 3,232,000 acres. There are 23,000 acres of Class IIw and IIIw Cropland and 17,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural needs for rural area preservation should be implemented. In considering investments for EQ drainage demands should be met. Meeting drainage demands will provide rural area assistance important to regional development.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	8	0	8	517	56			
NATIONAL EFFICIENCY									
	1980	2	0	2	129	14	28	11	.06
	2000	6	1	7	420	46	92	37	.19
	2020	4	3	7	355	38	76	30	.12
REGIONAL DEVELOPMENT									
	1980	4	1	5	291	32	53	24 to 77	.12
	2000	8	3	11	614	66	109	48 to 157	.25
	2020	3	8	11	452	49	81	36 to 117	.09
ENVIRONMENTAL QUALITY									
	1980	4	0	4	258	28	46	20 to 66	.12
	2000	8	1	9	549	60	99	44 to 143	.25
	2020	3	3	6	291	32	53	24 to 77	.09

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-18
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 8. CONNECTICUT RIVER BASIN

Wetlands comprise 8% of Area 8's 7,128,000 acres. There are 125,000 acres of Class IIw and IIIw Cropland and 101,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Careful selection of needs by reaches of the river should be made. Drainage that helps to preserve farm landscapes deserves special consideration.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	45	0	45	2907	315			
NATIONAL EFFICIENCY									
	1980	15	0	15	969	105	210	84	.21
	2000	36	5	41	2487	270	540	216	.51
	2020	13	15	28	1324	144	288	115	.18
REGIONAL DEVELOPMENT									
	1980	23	5	28	1647	178	294	130 to 424	.32
	2000	45	15	60	3391	368	607	269 to 876	.63
	2020	12	45	57	2228	242	399	177 to 576	.17
ENVIRONMENTAL QUALITY									
	1980	23	0	23	1486	161	266	118 to 384	.32
	2000	45	5	50	3068	332	548	242 to 790	.63
	2020	12	15	27	1260	136	224	99 to 323	.17

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-19
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 9. SOUTHEASTERN NEW ENGLAND

Wetlands comprise 18% of Area 9's 2,928,000 acres. There are 16,000 acres of Class IIw and IIIw Cropland and 10,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Small NE demands should receive consideration. Opportunities toward RD and EQ are limited.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	6	0	6	388	42			
NATIONAL EFFICIENCY									
	1980	2	0	2	129	14	28	11	.07
	2000	5	1	6	355	38	76	30	.17
	2020	1	2	3	129	14	28	11	.03
REGIONAL DEVELOPMENT									
	1980	3	1	4	226	24	40	18 to 58	.10
	2000	6	2	8	452	49	81	36 to 117	.20
	2020	1	4	5	194	21	35	16 to 51	.03
ENVIRONMENTAL QUALITY									
	1980	3	0	3	194	21	35	16 to 51	.10
	2000	6	1	7	420	46	76	34 to 110	.20
	2020	1	2	3	129	14	23	10 to 33	.03

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-20
AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 10. THAMES AND HOUSATONIC RIVER BASINS

Wetlands comprise 15% of Area 10's 2,916,000 acres. There are 53,000 acres of Class IIw and IIIw Cropland and 13,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural water resource demands associated with the preservation of farm landscapes deserve special emphasis; drainage demands toward EQ should be met. At least portions of the projected demands should be met for NE investments.

Emphasized Objective	Time Frame: Year	Land Drainage Demands 1/ (1000 acres): Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars): One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective: NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	19	0	19	1227	133			
NATIONAL EFFICIENCY									
	1980	6	0	6	388	42	84	34	.21
	2000	15	1	16	1001	108	216	86	.51
	2020	6	2	8	452	49	98	39	.21
REGIONAL DEVELOPMENT									
	1980	9	1	10	614	66	109	48 to 157	.31
	2000	19	2	21	1292	140	231	102 to 333	.65
	2020	6	6	12	581	63	104	46 to 150	.21
ENVIRONMENTAL QUALITY									
	1980	9	0	9	581	63	104	46 to 150	.31
	2000	19	1	20	1260	136	224	99 to 323	.65
	2020	6	2	8	452	49	81	36 to 117	.21

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-21
AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION C

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	204	0	204	7944	885			
NATIONAL EFFICIENCY									
	1980	62	0	62	2414	269	538	216	
	2000	163	26	189	6853	764	1528	611	
	2020	103	77	180	5510	615	1230	492	
REGIONAL DEVELOPMENT									
	1980	102	26	128	4478	499	824	364 to 1188	
	2000	204	77	281	9442	1052	1736	768 to 2504	
	2020	104	231	335	8547	953	1573	696 to 2269	
ENVIRONMENTAL QUALITY									
	1980	102	0	102	3972	442	729	345 to 1124	
	2000	204	26	230	8450	941	1553	687 to 2240	
	2020	104	77	181	5549	619	1021	451 to 1472	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-22

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 11. LAKE CHAMPLAIN AND ST. LAWRENCE RIVER DRAINAGE

Wetlands comprise 20% of Area 11's 7,616,000 acres. There are 414,000 acres of Class IIw and IIIw Cropland and 279,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural demands including drainage should receive emphasis for NE, RD and EQ investments. Meeting these demands will encourage agricultural development and help preserve a rural landscape.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	138	0	138	5374	599			
NATIONAL EFFICIENCY									
	1980	42	0	42	1635	182	364	146	.55
	2000	110	14	124	4556	508	1016	406	1.44
	2020	69	42	111	3505	391	782	313	.90
REGIONAL DEVELOPMENT									
	1980	69	14	83	2959	330	545	241 to 786	.90
	2000	138	42	180	6191	690	1139	504 to 1643	1.81
	2020	69	126	195	5140	573	946	419 to 1365	.90
ENVIRONMENTAL QUALITY									
	1980	69	0	69	2687	299	493	218 to 711	.90
	2000	138	14	152	5646	629	1038	459 to 1497	1.81
	2020	69	42	111	3505	391	645	285 to 930	.90

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-23

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 12. HUDSON RIVER BASIN

Wetlands comprise 15% of Area 12's 8,554,000 acres. There are 200,000 acres of Class IIw and IIIw Cropland and 234,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Drainage is one of the demands that tend to preserve agricultural landscape and is important in this area; EQ demands should be met in full.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/: (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	66	0	66	2570	286			
NATIONAL EFFICIENCY									
	1980	20	0	20	779	87	174	70	.23
	2000	53	12	65	2297	256	512	205	.62
	2020	34	35	69	2005	224	448	179	.40
REGIONAL DEVELOPMENT									
	1980	33	12	45	1519	169	279	123 to 402	.39
	2000	66	35	101	3251	362	597	264 to 861	.77
	2020	35	105	140	3407	380	627	277 to 904	.41
ENVIRONMENTAL QUALITY									
	1980	33	0	33	1285	143	236	127 to 413	.39
	2000	66	12	78	2804	312	515	228 to 743	.77
	2020	35	35	70	2044	228	376	166 to 542	.41

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-24

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 13. SOUTHERN NEW YORK METROPOLITAN AREA

Wetlands comprise 1% of Area 13's 1,217,000 acres. There is no Class IIw and IIIw Cropland and 1,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Small scattered areas require drainage. Food and Fiber production is small and is decreasing; remaining agricultural land is giving way to urban development. Incomes are above national averages. Drainage appears to have no opportunity for investment consideration.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966								
NATIONAL EFFICIENCY									
	1980								
	2000								
	2020								
REGIONAL DEVELOPMENT		SMALL WETLAND AREAS PRECLUDE SUMMARIZATION							
	1980								
	2000								
	2020								
ENVIRONMENTAL QUALITY									
	1980								
	2000								
	2020								

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-25

AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION D

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	146	0	146	8504	953			
NATIONAL EFFICIENCY									
	1980	44	0	44	2562	287	574	229	
	2000	116	14	130	7164	803	1606	642	
	2020	31	44	75	3087	346	692	277	
REGIONAL DEVELOPMENT									
	1980	74	14	88	4717	528	871	385 to 1256	
	2000	146	44	190	9785	1097	1811	801 to 2612	
	2020	19	133	152	4979	559	923	409 to 1332	
ENVIRONMENTAL QUALITY									
	1980	74	0	74	4309	483	797	352 to 1149	
	2000	146	14	160	8912	999	1649	730 to 2279	
	2020	19	44	63	2388	268	442	196 to 638	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-26

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 14. NORTHERN NEW JERSEY

Wetlands comprise 23% of Area 14's 1,520,000 acres. There are 51,000 acres of Class IIw and IIIw Cropland and no Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Drainage can contribute significantly to environmental quality in this area. Scattered installations will have little effect on peak runoff.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/: (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	19	0	19	1107	124			
NATIONAL EFFICIENCY									
	1980	6	0	6	349	39	78	31	.39
	2000	15	0	15	874	98	196	78	.99
	2020	4	0	4	233	26	52	21	.26
REGIONAL DEVELOPMENT									
	1980	10	0	10	582	65	107	47 to 154	.66
	2000	19	0	19	1107	124	205	91 to 296	1.25
	2020	3	0	3	175	20	33	15 to 48	.19
ENVIRONMENTAL QUALITY									
	1980	10	0	10	582	65	107	47 to 154	.66
	2000	19	0	19	1107	124	205	91 to 196	1.25
	2020	3	0	3	175	20	33	15 to 48	.19

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-27

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 15. DELAWARE RIVER BASIN

Wetlands comprise 17% of Area 15's 8,169,000 acres. There are 285,000 acres of Class IIw and IIIw Cropland and 126,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Drainage in rural areas can contribute toward NE and RD; the group of agricultural demands including drainage contributes to the maintenance of rural landscapes and they should be implemented for the EQ objective.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	108	0	108	6290	705			
NATIONAL EFFICIENCY									
	1980	32	0	32	1864	209	418	167	.39
	2000	86	6	92	5183	581	1162	465	1.05
	2020	24	19	43	1951	219	438	175	.29
REGIONAL DEVELOPMENT									
	1980	54	6	60	3320	372	614	272 to 886	.66
	2000	108	19	127	6843	767	1266	560 to 1826	1.32
	2020	15	57	72	2533	284	469	208 to 677	.18
ENVIRONMENTAL QUALITY									
	1980	54	0	54	3145	353	583	258 to 841	.66
	2000	108	6	114	6465	725	1196	529 to 1725	1.32
	2020	15	19	34	1427	160	264	117 to 381	.18

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-28

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 16. COASTAL NEW JERSEY

Wetlands comprise 35% of Area 16's 1,532,000 acres. There are 49,000 acres of Class IIw and IIIw Cropland and 168,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Agricultural demands intended to encourage agricultural production should be met. Planning and installation are necessary so that visual, cultural and production needs can be met. Drainage provides opportunity toward all three objectives; demands need to be fulfilled.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	19	0	19	1107	124			
NATIONAL EFFICIENCY									
	1980	6	0	6	349	39	78	31	.39
	2000	15	8	23	1107	124	248	99	.98
	2020	3	25	28	903	101	202	81	.20
REGIONAL DEVELOPMENT									
	1980	10	8	18	815	91	150	66 to 216	.65
	2000	19	25	44	1835	206	340	150 to 490	1.24
	2020	1	76	77	2271	255	421	186 to 607	.07
ENVIRONMENTAL QUALITY									
	1980	10	0	10	582	65	107	47 to 154	.65
	2000	19	8	27	1340	150	248	110 to 358	1.24
	2020	1	25	26	786	88	145	64 to 209	.07

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-29

AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION E

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	531	0	531	24266	2814			
NATIONAL EFFICIENCY									
	1980	159	0	159	7267	842	1684	674	
	2000	266	19	285	12591	1460	2020	1168	
	2020	-	57	57	1303	151	302	120	
REGIONAL DEVELOPMENT									
	1980	266	19	285	12591	1460	2409	1066 to 3475	
	2000	266	57	323	13459	1561	2576	1140 to 3716	
	2020	-	171	171	3907	454	749	331 to 1080	
ENVIRONMENTAL QUALITY									
	1980	266	0	266	12156	1410	2327	1029 to 3356	
	2000	266	19	285	12545	1454	2399	1061 to 3460	
	2020	-	57	57	1303	151	250	111 to 361	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-30

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 17. SUSQUEHANNA RIVER BASIN

Wetlands comprise 10% of Area 17's 17,607,000 acres. There are 454,000 acres of Class IIw and IIIw Cropland and 149,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: Drainage needs and consequently the significance are small. Half of the total area requiring drainage has already been treated. The remaining demands should receive consideration toward all objectives.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	227	0	227	10373	1203			
NATIONAL EFFICIENCY									
	1980	68	0	68	3108	360	720	288	.39
	2000	114	7	121	5370	623	1246	498	.65
	2020	-	22	22	503	58	116	46	-
REGIONAL DEVELOPMENT									
	1980	114	7	121	5370	623	1028	455 to 1483	.65
	2000	113	22	135	5667	657	1084	480 to 1564	.64
	2020	-	67	67	1531	178	294	130 to 424	-
ENVIRONMENTAL QUALITY									
	1980	114	0	114	5210	604	997	441 to 1438	.65
	2000	113	7	120	5324	617	1018	450 to 1468	.64
	2020	0	22	22	503	58	96	43 to 139	-

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-31

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 18. CHESAPEAKE BAY AND DELMARVA PENINSULA DRAINAGE

Wetlands comprise 42% of Area 18's 5,203,000 acres. There are 609,000 acres of Class IIw and IIIw Cropland and 231,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: RD. The maintenance of agriculture will be important.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	304	0	304	13893	1611			
NATIONAL EFFICIENCY									
	1980	91	0	91	4159	482	964	386	1.75
	2000	152	12	164	7221	837	1674	670	2.92
	2020	-	35	35	800	93	186	74	-
REGIONAL DEVELOPMENT									
	1980	152	12	164	7221	837	1381	611 to 1992	2.92
	2000	153	35	188	7792	904	1492	660 to 2152	2.94
	2020	-	104	104	2376	276	455	201 to 656	-
ENVIRONMENTAL QUALITY									
	1980	152	0	152	6946	806	1330	588 to 1918	2.92
	2000	153	12	165	7221	837	1381	611 to 1992	2.94
	2020	-	35	35	800	93	154	68 to 222	-

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-32

AGRICULTURAL LAND DRAINAGE SUMMARY
SUB-REGION F

Emphasized Objective	Time Frame: Year	Land Drainage Demands 1/ (1000 acres): Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars): One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective: NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	203	0	203	13316	1557			
NATIONAL EFFICIENCY									
	1980	61	0	61	4001	467	934	374	
	2000	100	36	136	7739	905	1810	723	
	2020	-	107	107	3509	411	822	328	
REGIONAL DEVELOPMENT									
	1980	101	36	137	7805	912	1506	666 to 2172	
	2000	100	107	207	10068	1177	1942	859 to 2801	
	2020	-	322	322	10559	1235	2038	902 to 2940	
ENVIRONMENTAL QUALITY									
	1980	101	0	101	6225	775	1279	565 to 1844	
	2000	100	36	136	7739	905	1494	661 to 2155	
	2020	-	107	107	3509	411	679	301 to 980	

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-33

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 19. POTOMAC RIVER BASIN

Wetlands comprise 12% of Area 19's 9,389,000 acres. There are 215,000 acres of Class IIw and IIIw Cropland and 94,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: EQ and RD. Drainage will help maintain, preserve and develop rural agricultural areas.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	108	0	108	7084	828			
NATIONAL EFFICIENCY									
	1980	32	0	32	2099	245	490	196	.34
	2000	54	5	59	3706	433	866	346	.58
	2020	-	14	14	459	54	108	43	-
REGIONAL DEVELOPMENT									
	1980	54	5	59	3706	433	715	316 to 1031	.58
	2000	53	14	67	3935	460	759	336 to 1095	.56
	2020	-	42	42	1377	161	266	118 to 384	-
ENVIRONMENTAL QUALITY									
	1980	54	0	54	3542	414	683	302 to 985	.58
	2000	53	5	58	3640	426	703	311 to 1014	.56
	2020	-	14	14	459	54	89	39 to 128	-

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-34

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 20. RAPPAHANNOCK AND YORK RIVER BASINS

Wetlands comprise 21% of Area 20's 3,840,000 acres. There are 100,000 acres of Class IIw and IIIw Cropland and 322,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: EQ and RD. Drainage will help encourage and preserve agricultural economies.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	50	0	50	3280	384			
NATIONAL EFFICIENCY									
	1980	15	0	15	983	115	230	92	.39
	2000	25	16	41	2164	253	506	202	.65
	2020	-	48	48	1574	184	368	147	-
REGIONAL DEVELOPMENT									
	1980	25	16	41	2164	253	418	185 to 603	.65
	2000	25	48	73	3214	376	620	274 to 894	.65
	2020	-	145	145	4755	556	917	406 to 1323	-
ENVIRONMENTAL QUALITY									
	1980	25	0	25	1640	192	317	140 to 457	.65
	2000	25	16	41	2164	253	418	185 to 603	.65
	2020	-	48	48	1574	184	304	135 to 439	-

1/ The values shown in the table are incremental.
2/ Price base 1966.

TABLE J-35

AGRICULTURAL LAND DRAINAGE SUMMARY
AREA 21. JAMES RIVER BASIN

Wetlands comprise 13% of Area 21's 6,784,000 acres. There are 89,000 acres of Class IIw and IIIw Cropland and 300,000 acres of Class IIw, IIIw, and IVw Forest on types practical to drain. Table J-3 shows the kind of practices (devices) already applied.

OPPORTUNITIES TOWARD OBJECTIVES: EQ and RD. Preservation of Agriculture and the rural economy are important.

Emphasized Objective	Time Frame Year	Land Drainage Demands 1/ (1000 acres) Crop-land	Forest	Total	Cost 1/ 2/ (1000 Dollars) One Time	Average Annual	Benefit 1/ 2/ Toward Each Objective NE (Average Annual $1000)	RD	EQ (% Open Land)
	1966	45	0	45	2952	345			
NATIONAL EFFICIENCY									
	1980	14	0	14	918	107	214	86	.21
	2000	21	15	36	1869	219	438	175	.31
	2020	-	45	45	1476	173	346	138	-
REGIONAL DEVELOPMENT									
	1980	22	15	37	1935	226	373	165 to 538	.32
	2000	22	45	67	2919	341	563	249 to 812	.32
	2020	-	135	135	4427	518	855	378 to 1233	-
ENVIRONMENTAL QUALITY									
	1980	22	0	22	1443	169	279	123 to 402	.32
	2000	22	15	37	1935	226	373	165 to 538	.32
	2020	-	45	45	1476	173	286	127 to 413	-

1/ The values shown in the table are incremental.
2/ Price base 1966.

CHAPTER 3. MAJOR DRAINAGE

The U. S. Army Corps of Engineers responsibility for major drainage was authorized by the Flood Control Act of 1944 (Public Law 534), in which flood control is defined to include major drainage. The Corps mission involves estimating the need for major drainage and for pertinent drainage measures, computing costs and benefits, coordinating is major drainage projects with other concerned agencies, and implementing such drainage designs as directed by specific authorities.

Federal major drainage improvements are defined to mean major outlet channels serving land drainage systems. Major drainage improvements comprise improvement of natural waterway including its tributaries, or of an existing artificial waterway, or construction of new artificial drainage channels to provide outlets for water collected or to be collected by the drainage works of organized districts or municipalities. Drainage problems in urban and industrial areas are considered to come within the intent of the 1944 Act, in so far as the major outlet works do not supplant works that should normally be provided by local interests such as municipal storm sewerage and drainage improvements. Interior drainage problems may be encountered in or result from projects for local flood protection of both agricultural and urban areas, and are distinguished from major drainage improvements under the 1944 Act. Major drainage administrative policy is based on cost sharing for reclamation by irrigation in the West, it provides for equal sharing of the first costs of the major outlets, including lands, between the Federal Government and local interests, with the latter to operate and maintain the project after construction, and to provide all upstream drainage improvements.

A major drainage program for the North Atlantic Region was not formulated because it would require the disaggregation of major drainage from flood control, tidal control navigation, and other study disciplines to project major drainage by individual project resolution an effort precluded by the scope limitations of the Study. The major drainage presentation is, therefore, a review of the current major drainage projects under consideration in the North Atlantic Region.

MAJOR DRAINAGE PROJECTS

JERSEY MEADOWS

Authorized under Section 206 of the 1958 Flood Control Act, the Jersey Meadows project is under the jurisdiction of the New York District, U. S. Army Corps of Engineer. Its objective is the formulation of a comprehensive plan for the balanced and coordinated development of the Newark Bay, Kill Van Kull and Arthur Kill area, that would produce the maximum economic return. Consideration is being given to upstream river and tidal action control, major drainage, recreation and other related problems.

The study area includes the Elizabeth River Basin the Hackensack River Basin, Newark Bay, Kill Van Kull and Arthur Kill, and is located in NAR Area 14.

Local and Congressional interest is high. The meadows is a vast section of unused land which has lain dormant because of its swamplike character. Only about 10% of the area has been developed. Tidal and fluvial flooding occur frequently because of the low land elevations. The meadows are of regional importance for potential development because of their location in the heart of the New York Metropolitan Area. Hackensack Area is approximately equal to Manhattan in size. Coordinated and planned development becomes increasingly difficult in fact of active, uncontrolled and scattered development which is accelerating.

The study was pursued into three parts as follows: Elizabeth River; Hackensack Meadows; and Newark Bay, Kill Van Kull and Arthur Kill. The Elizabeth River Basin (Flood Control) report was submitted to Congress and the project authorized in the Flood Control Act of 1965. Under the Hackensack Meadows study, seven alternative plans were developed, and the optimum plan selected. The draft report was completed, and a draft of a report to obtain Bureau of the Budget (now Office of Management and Budget) approval for proposed cost sharing was also approved.

No work has been done on the Newark Bay, Kill Van Kull and Arthur Kill portion of the study.

Tentative recommendations for the Hackensack Meadows portion include a tidal barrier at mile 4.3 of the Hackensack River, incorporating sector gates, with associated levees, walls and interior drainage.

Because of the inability of local interests to agree on development plans for the area, progress on the report has been slight in the past few years. As a result, the anticipated completion date has been revised from Fiscal Year 1972 to FY 1974.

In November 1968, the New Jersey legislature established the Hackensack Meadowlands Development Commission to implement meadows development and furnish local cooperation.

PASSAIC RIVER

Authorized under Section 6 of the 1936 Flood Control Act, and further under a 13 June 1956 House Committee Resolution (Ramapo River - tributary), this study is being conducted by the U. S. Army Corps of Engineers New York District.

The Passaic Basin covers 935 square miles in Northeastern New Jersey and Southeastern New York, and is located in NAR Area 14. It includes portions of Passaic, Morris, Bergen, Sussex and Union Counties in New Jersey, and Orange and Rockland Counties in New York.

The area is heavily developed with a mix of housing, commerce and industry and its flood damage potential is extremely high. A recurrence of the 1903 flood of record would cause projected damages of about $270 million. The recent five year drought, which ended in 1967, highlighted potential water supply problems.

The Corps developed feasible flood control plans in March 1939 and October 1948, which were not accepted by local interests. Under a new study which was started in 1957, four revised plans emphasizing reclamation, flood prevention, multiple purpose development, and conservation, were developed. These were presented to the New Jersey Governor in March 1968 and before a public hearing, and the multiple purpose plan was agreed upon. Later, the report was updated to include May 1968 flood data. In December 1969, a letter of intent on local cooperation was received from the Governor.

Remaining work includes the revision of cost and benefit data, and the submission of the final report.

Delays have been experienced, largely because of the complex situation caused by the large population and diversity of the area. Conflicts between upper and lower basin interests and the lack of a basin-wide coordinating organization make the selection of an acceptable and effective solution difficult.

The recommended plan includes two multiple-purpose reservoirs and local protection where justified. It provides for water supply, flood prevention, recreation and low-flow augmentation.

ANACOSTIA RIVER AND FLATS

Current study progress, under the authority of a 4 March 1950 Senate Committee Resolution, is under the jurisdiction of the Baltimore

District, U. S. Army Corps of Engineers. Located in NAR Area 19, the study area includes the Anacostia River in the District of Columbia.

The project objective is the preparation of a plan, including levees, floodwalls and improved navigation channels, for development of the Anacostia Basin. The completed report will review present development, and establish a cost estimate, and its allocation between Federal and non-Federal interests, for executing the project plan.

Originally authorized in 1911, active project construction was in progress from 1912 to 1942, with the expenditure of some $4 million. While the project is about 70% complete, half of the study area is only partially reclaimed.

A draft report, under the most recent study, has been submitted to the National Park Service, the National Capital Planning Commission and the D. C. Government. Comments received from these agencies indicate that further development will necessitate further coordination and extensive planning effort.

Plans are being executed by the National Park Service for an extensive park and recreation along the lower reaches of the Anacostia from the Maryland-D. C. Border to the Potomac River.

Use of the area for a proposed highway and for waste disposal has been proposed by the District of Columbia. These and other land use problems affect the completion of the study.

Submission of the report, in response to the Senate Resolution will be deferred, until the proposed recreation development has been fully considered, and a determination made as to the further participation of the Corps of Engineers.

VIRGINIA BEACH STREAMS

Located in the City of Virginia Beach, Va., in NAR Area 21, this project is under the jurisdiction of the Norfolk District, U. S. Army Corps of Engineers, with the objective of determining the feasibility of a system of canals for navigation and improving drainage.

The City of Virginia Beach, with a rapidly growing population, wanted the study in order to establish a water drainage plan, including a network of canals, to relieve flooding conditions and to provide for recreational boating.

The study was authorized under the following legislative actions:

Senate Resolution, 9 June 1948, to review Senate Document 23, 71st Congress, 1st Session, with view to improving drainage adjacent to Back Bay and North Landing River.

House Resolution, 28 April 1965 (same as above Senate Resolution).

House Resolution, 24 June 1965, to review Senate Exec. Document 104, 46th Congress, 2d Session, with view to providing a system of canals in City of Virginia Beach in the interest of navigation improvements.

Study progress is as follows:

General: The study of the Back Bay portion of study was initiated in 1948 with a survey of the flooding of farmlands adjacent to the Back Bay region. Work was suspended in 1959 because of a lack of funds, and resumed during Fiscal Year 1967 in its present scope.

Fiscal Year 1969: Completed a preliminary study and developed plan of improvement of Canal No. 2 of the five primary canals to be studies; initiated preliminary study of Canal No. 4; established contact with local, State and Federal agencies.

Fiscal Year 1970: Complete preliminary study and plan of improvement of Canal No. 4; prepare and furnish a preliminary report on Canal No. 2 and obtain comments and an expression of interest from city officials; initiate study to determine feasibility of maintaining an appropriate depth of navigation into Rudee Inlet; initiate preliminary Study of Canal No. 3; continue coordination with local, State and Federal agencies.

Fiscal Year 1971: Completed study and plan of improvement for Canals Nos. 3 and 5, Rudee Inlet, and alleviation of flooding from Back Bay.

Remaining work includes the completion of preliminary study and plan of improvement of Canals No. 3 and 5 and Rudee Inlet; the establishment of a plan for major drainage improvement and navigation; the estimation of project and apportion costs; coordination of the plan with local, State and Federal agencies; the final design and estimation of cost, benefits and cost sharing; securing assurances of local cooperation and then finalizing the report.

Tentative recommendations include the establishment of a master drainage plan including a network of canals strategically located throughout the City of Virginia Beach to relieve flood conditions and provide for recreational boating.

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